

Lesson Classification: UNCLASSIFIED

Lesson ID: 08135-90672

Title: Urban Warfare and Other Operations: The Accuracy of Mortar Fire

Operation/Exercise Name: URBAN WARFARE

Observed:

Originator: MCPDFALLBROOK

POC: CARL SHAVER Commercial: (760)731-3668 DSN: 8733668

5. (U) OBSERVATION:

Mortars may ultimately become the indirect weapon of choice in built-up areas because their high angle trajectories are more effective in the so-called "urban canyon", and because the man-portability of 60mm and 81mm systems reduce the logistic footprint ashore and support small-unit urban operations. Also, direct-support mortar platoons can respond faster than artillery, and the urban setting offers cover so that mortars can stay close to the fight while being less exposed. Accurate mortar fire is important to reduce civilian casualties and collateral damage, while increasing its effectiveness. Because city firefights often occur at close range, it can be argued that accuracy is more important in urban versus rural areas. Accurate mortar fire is important in other operations also. For example, mortars have an important role in amphibious operations, especially before artillery comes ashore. Also, defense of firebases often calls for accurate, long range mortar fire from other firebases; accuracy is critical when close-in fires around the perimeter are needed. Accurate fire implies that the 1st round hits the target. Precise fire implies that the following rounds hit the same spot as the first round.

A key piece of the puzzle has not been presented however - the accuracy of current mortar systems and the possible accuracy of future mortar systems. How accurate is the fire support now and will the USMC (or any service) ever be able to significantly reduce the risk of danger-close missions or, as it has been called in the urban context, "next-door fire missions", from afar?

Accurate fire can be achieved by using either predicted or adjusted fire control techniques. Adjusted fire is controlled or "adjusted" by an observer who can see the rounds functioning; this technique often relies on a registration mission and is the most common technique for Marine Corps mortar fire. With the tools available to today's Marines, adjusted fire is more accurate than predicted fire. Predicted fire control is currently used by the artillery community and attempts to account for all nonstandard conditions (weapon, weather, ammunition, etc.). Additionally, predicted fire incorporates accurate weapon, observer, and target location. The goal of the extra hardware and effort involved in predicted fire is to attain accurate first-round fires-for-effect on the target, without a registration mission. In urban settings, predicted mortar fire will become more important, as mortar crews will rarely see their target and forward observers will be less able to accurately adjust fire because of buildings and other obstructions. Also because

adjusted fire may cause additional collateral damage, alert the enemy, draw counter-battery fire, and expend valuable ammunition.

6. (U) DISCUSSION:

Each "lot" of ammunition can be assembled from different component lots using different processes, so the performance of two different ammunition lots may vary. Generally, firing tables are generated from the initial lot of ammunition, so product improvements or any manufacturing tolerance slip can render the firing tables less accurate. (Accuracy can be defined as the difference between the firing table solution and actual performance.) It is important to remember that the same data used to make tabular firing tables also are used to develop computer-based fire control systems and graphical firing tables.

Tables 1 and 2 from surveillance tests show the accuracy of 60mm and 81mm mortar fire using the current ammunition and firing tables. The below 1st-round errors assume no wind, 70oF, standard barometric pressure and density, and that each projectile leave the weapon with the expected velocity. Currently, Marine mortarmen in the field do not have the training or equipment to correct for most of these effects, except by firing registration missions with each ammunition lot, so in practice the 1st-round will usually miss the target by even more, especially at high charge. Human error in computing the ballistic solution is often even more pronounced; Tables 1 and 2 show the best accuracy the firing tables or ballistic computers will allow.

Table 1: 60mm Mortar Accuracy

Item Table*	Charge	Expected Range (m)	Lot-to-Lot Variation from Firing
B642; M720 HE	0	407	8m to 4m short
	4	3250	93m to 47m short
B643; M888 HE	0	407	9m short to 2m long
	4	3200	59m to 169m long
B646; M722 WP	0	407	4m short to 7m long
	4	3200	107m to 30m short
B647; M721 Illum	1	397	10m to 36m long
	4	3036	1m to 119m long

* assuming a warm tube and a seated baseplate

Table 2: 81mm Mortar Accuracy

Item Table*	Charge	Expected Range (m)	Lot-to-Lot Variation from Firing
C256; M374A3 HE	1	1200	10m short to 13m long
	4	4000	42m short to 63m long

C868; M821 HE	0	482	4m short to 89m long
	4	5608	163m short to 36m long
C869; M889 HE	0	468	21m short to 8m long
	4	5395	3m to 252m long
C870; M819 RP	1	413	36m to 24m short
	4	907	103m to 24m short
C871; M853A1 Illum	1	1372	263m to 139m short
	4	5056	203m to 56m short

* assuming a warm tube and a seated baseplate

HE = high explosive

Illum = illumination

WP = white phosphorous

RP = red phosphorous

PD = point detonating

MO = multi-option

m = meters

Considering the effective radii of high explosive, smoke, and illumination ammunition, the accuracy at low charge is generally adequate for use against personnel and materiel, and for screening, etc., though improvements can and should be made. At high charge, many first volleys will be less effective. Mortars more effectively complete their primary mission of suppression when they function 20 meters for example, versus 150 meters, from the target, especially in the city.

The Mortar Gunnery field manual (FM 23-91) advises that "each lot of ammunition has its own performance level (muzzle velocity and range) when related to the same mortar barrel." Tables 1 and 2 show that the accuracy of a specific ammunition model can vary greatly at times. This is mostly due to differences between ammunition lots. The "grouping" (i.e. precision) within each lot is usually good, but switching to different ammunition lots often means the rounds will fall a significant distance from the previous lot, and the observer will have to adjust fire back to the target.

Though mortars are lighter and less expensive than artillery, they are not inherently less accurate. When compared at similar muzzle velocities and quadrant elevations in Table 3, we see that mortars and artillery have similar precision and so are capable of similar accuracy. This suggests that future mortars (such as the proposed Armored Mortar System) could also possess accuracy comparable to that of artillery. Table 3 indicates that for both mortars and artillery, precision is, in general, a function of the size of the projectile. For mortars to remain effective, the smaller lethal radius of mortar projectiles demands they be more precise, especially in urban areas. (The Range Probable Error (RPE) data were taken from published firing tables. Where more than one charge is capable of reaching a given range, the values in Table 3 represent the RPE for the closest common muzzle velocity.)

Table 3: Artillery and Mortar Range Probable Errors (meters) for High Angle Fire

Range (meters)	M224 Mortar	M252 Mortar	M119 Howitzer	M120 Mortar	M198 Howitzer
500	3	4		12	
1500	10	12		18	
2500	17	15	20	21	25
3500	23	16	22	25	25
4500		20	26	29	27
5500		18	32	33	35
6500			25	28	30

The table demonstrates that mortars are as precise as artillery. Therefore, any Marine Corps investment in mortar hardware, training, etc. would not be undercut by alleged inaccuracies inherent in mortars, as is commonly believed. FM 6-40 lists the five essential elements for successful predicted fire as: (1) accurate target location and size, (2) accurate firing unit location, (3) weapon and ammunition information, (4) current met information, and (5) computational procedures. In general, mortar fire is more precise than that of artillery, however for predicted mortar fire to deliver accurate 1st-rounds, mortar crews require similar training, fire control information and equipment as artillery units.

To improve the current stockpile's accuracy, requirements documents for future mortar systems would have to address both precision and accuracy (Currently, only precision is mentioned.), and to specify that precision and accuracy requirements be met when switching between ammunition lot numbers. Firing tables, ballistic computers, and ammunition specifications can be updated relatively easily, but in some cases large round-to-round and lot-to-lot differences were manufactured into the ammunition itself, and much of this ammunition will be in the USMC inventory for years. Maximizing accuracy requires that other factors be addressed. Assuming the ballistic solution was computed correctly the top three sources of 1st-round error for the USMC are: (1st) weather, (2nd) target and weapon location error, and (3rd) muzzle velocity variation.

If the goal is to make the current stockpile more effective, not only should the firing tables, ballistic computers, and ammunition specifications be changed, but up to date meteorological information should be used by mortar platoons, LAV-M companies, etc. This would reduce mortar-fire errors even more because an average weather day (5-knot surface wind) can increase the 1st-round miss by 50 meters, and a windy day (20-knot surface wind) can increase the miss by 200 meters. This is in addition to the miss distances listed in Tables 1 and 2. Distant mortar fire stands a reasonable chance of hitting the target (meaning the target is within the round's effective radius) with the first volley only by first taking meteorological conditions into account. To address the remaining error, like location and muzzle velocity variation, the USMC could also consider hardware purchases. The Army has taken the lead on several initiatives to improve weapon and target location and other sources of error. For example, the Mortar

Fire Control System currently being developed by the Army will digitally receive meteorological information and incorporate it into the ballistic solution; the Army plans to incorporate this capability into the XM30 Mortar Ballistic Computer. USMC leveraging on such programs could be necessary to maximize the accuracy of the current stockpile. When possible, firing only one ammunition lot per fire mission is recommended as an additional way to improve accuracy.

Recent improvements have made mortars more precise (i.e. smaller range probable errors) under most conditions than 105mm or 155mm artillery, as shown in Table 3, but artillery 1st-round accuracy is better in part because firing solutions address meteorological conditions, gun positions are surveyed, and muzzle velocities are monitored. For mortars to achieve accurate predicted fire, it is essential that the firing unit use timely meteorological messages, ballistic computers, and muzzle velocity measurement, along with GPS or accurate surveying of gun positions. Changes to firing tables, ballistic computers, and ammunition production are also necessary. Institutionalizing information feedback from surveillance and lot acceptance tests would allow for continuous upgrades to firing tables. This would make first-volley hits with mortars much more likely. It would also increase supported units' confidence in mortars for danger-close or "next-door fire missions". However the question remains as to whether Marines would be comfortable in calling for "next-door fire missions" from significant distances. With dumb ammunition, probably not.

Smart mortar munitions reduce the need for meteorological support and monitoring muzzle velocity, and will have a high probability of hitting the target with the first round. Though currently expensive, the technology will eventually become cheaper and smaller, allowing affordable 81mm and then 60mm smart rounds.

The 120mm Autonomous Mortar (February 1998, Gazette) and LAV-120mm Armored Mortar System (February 1998, Gazette) are both under experimentation. Both incorporate GPS, though neither calculates fire solutions for non-standard weather or muzzle velocities. Because weather is the largest source of 1st-round error, it becomes more important to use firing table met corrections as mortar ranges and times of flight increase.

7. (U) LESSON LEARNED:

Mortar fire can be as accurate as artillery fire. However, the current equipment, gunnery procedures, and mortar ammunition may not meet the future USMC need for very accurate fire in urban combat and other operations. The 1st-round miss distances and lot-to-lot variation listed in Tables 1 and 2 can help the users identify a capability shortcoming, if the current stockpile's accuracy is not acceptable. Changes to firing tables, mortar ballistic computers, and future ammunition production are needed to improve accuracy. Correcting for differences between ammunition lots is also required. These improvements would significantly increase the accuracy of the current stockpile, but users would need to correct for meteorological conditions before firing commences to stand a chance of 1st-round hits. Surveyed mortar positions, better target locating, and correcting for muzzle velocity variation would further increase the accuracy of the mortar

fire. Also, requirements documents for mortar systems would need to specify both precision and accuracy even when switching between ammunition lot numbers.

Even with these improvements, mortars would probably not allow "next door fire missions" without significant risk to friendly forces. The best way to reasonably ensure 1st-round hits is with smart mortar munitions, since they do not rely so heavily upon making adjustments for met and muzzle velocity.

8. (U) RECOMMENDED ACTION:
None.

9. (U) COMMENTS:
None.

* * * * *